

overall response

We appreciate both reviewers for taking the time to review the manuscript a second time and provide constructive reviews. Below we describe the updates made in response to Reviewer 2 as well as a minor technical correction.

Response to Reviewer 2:

1. The manuscript does not state that ice shelf melting directly contributes to sea level rise. It is correctly stated that ice shelf thinning reduces the buttressing effect which leads to enhanced ice discharge across the grounding line, which does contribute to sea level rise. No revisions are necessary in response to this point.

2. In response to the points made by the Reviewer under 2), we revise the meltwater experiment description paragraph to keep it focused on the freshwater budget, not on the processes contributing to sea level rise. We acknowledge the distinctions between the sea level budget and the freshwater budget that the Reviewer describes. Focusing this paragraph on the freshwater budget should avoid confusion between the processes involved in the freshwater budget and those involved in the sea level budget. The freshwater budget is relevant to the CESM1-AIS meltwater experiment, as it is freshwater fluxes that are modified by the experimental design, not ocean volume or mass.

here is the revised description paragraph (lines 231-254):

"Anomalous freshwater fluxes from thinning ice shelves are not included in standard CMIP6 historical experiments nor the CESM2 experiments in Table 1. Recent work argues that ice sheet and ice shelf meltwater is a climate forcing that should be included in such experiments to enhance their accuracy in simulating historical trends and predicting future change (e.g. Rye et al., 2020; Roach et al., 2023; Schmidt et al., 2023; Sadai et al., 2025). Pauling et al. (2016) and Dong et al. (2022a) describe a meltwater hosing ensemble with CESM1 that spans 1980-2013. We utilize this ensemble (using the ensemble mean of 7 members where total anomalous freshwater flux is set to 2000 Gt yr⁻¹, prescribed at the front of ice shelves at depths of 100 - 200 m) for insight into the possible influence of meltwater on snow accumulation. A caveat is that the magnitude of the freshwater fluxes imposed in this ensemble is much larger than observational estimates (Pauling et al., 2016). In the observational record since 1990, anomalous freshwater fluxes to the ocean from the AIS and its ice shelves have exceeded 2000 Gt yr⁻¹ in a few years (Schmidt et al., 2025), but the time-averaged value is around 500 Gt yr⁻¹ (Swart et al., 2023). In reality, anomalous ice-to-ocean freshwater fluxes are approximately equally distributed between ice shelf basal melting and iceberg discharge (e.g. Coulon et al., 2024; Schmidt et al., 2025). Pauling et al. (2016) present an iceberg freshwater flux experiment, but we do not include it here due to the small ensemble size and the precedent of previous climate dynamics studies in using the larger CESM1 ice shelf basal melt ensemble (Dong et al., 2022a; Armour et al., 2024). Advantages of the CESM1 basal meltwater experiment are that it

captures the spatial pattern of anomalous meltwater forcing including its depth, and that it simulates significant responses in SSTs (Dong et al., 2022a), sea ice extent (Pauling et al., 2016) and transient climate sensitivity (Dong et al., 2022a). All CESM experiments conserve ocean mass and volume such that snow accumulating on the AIS in excess of 1 m is returned to the ocean, analogous to river runoff. The freshwater forcing in CESM1-AIS meltwater is implemented as an additional, negative salinity flux to estimate the climate impact of the mass imbalance of the AIS (Pauling et al., 2016)."

The above revision addresses Reviewer 2's comments because: a) It places the 2000 Gt yr⁻¹ in the context of more recent state-of-the art freshwater flux estimates from Schmidt et al (2025) and Swart et al (2023); b) It further clarifies that ocean mass and volume are conserved. It is the freshwater budget that is modified by the experimental design. There is no double counting of freshwater fluxes associated with changes in the hydrological cycle and those associated with Antarctic Ice Sheet mass loss; c) It does not state that ice shelf basal melting is more or less important than iceberg calving.

3. The caption of Figure 3 is revised to include the unsmoothed correlations and regression coefficients and the definition of relative mass.

Technical correction: The zonal wind anomaly timeseries from member 40, presented in Figure 1b, is updated using the CESM variable ubot (lowest model level zonal wind speed) in place of CESM variable u10 (scalar wind speed at nominal 10m height). The caption of Figure 1 is updated to clarify that ubot is used. Downstream figures 4e,h, 5 h,i and A4c,d are also updated. The updates are extremely subtle and do not significantly impact any results, interpretations, or conclusions of the paper.

A few other minor corrections to add missing words or correct misspellings are reflected in the tracked changes document.